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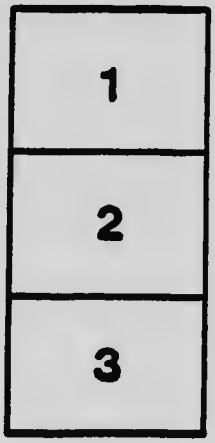

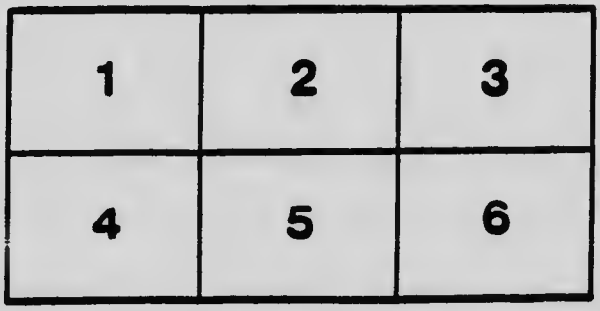

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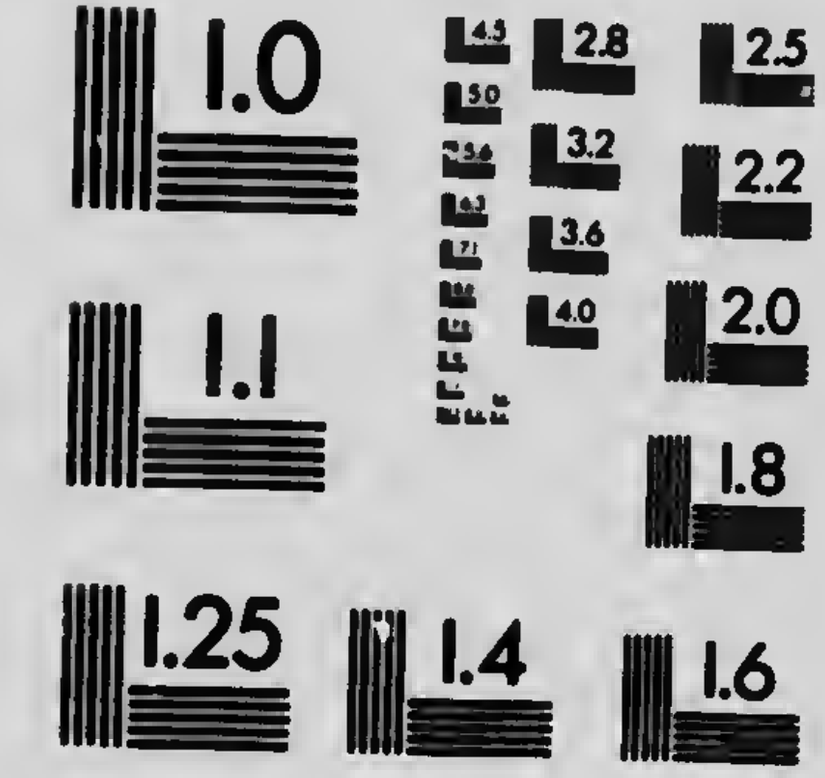

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DIVISION OF BOTANY

FLAX FOR FIBRE:

ITS CULTIVATION AND HANDLING

BY

J. ADAMS, M.A.
Assistant Dominion Botanist.

BULLETIN No. 28
Second Series

PUBLISHED BY AUTHORITY OF
Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa, Ont.

OTTAWA
GOVERNMENT PRINTING BUREAU
1916

544—1

DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

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OTTAWA, April 5, 1916.

The Honourable

The Minister of Agriculture,

Ottawa.

SIR,—I have the honour to transmit herewith, for your approval, the manuscript of Bulletin No. 28 of the Second Series, entitled "Flax for Fibre: Its Cultivation and Handling," which has been prepared by Mr. John Adams, Assistant Dominion Botanist.

The possibilities of producing flax for fibre in Canada have already been proved to be very considerable. It would seem wise, therefore, to do anything possible to encourage the growth of this industry in districts suited thereto at this time, when unusually high prices will serve as an impetus to its development and extension.

The accompanying brief bulletin on methods of growing and handling this crop will, I believe, be of much use to our farmers in this connection, and I have therefore to recommend that it be published at an early date.

I have the honour to be, sir,

Your obedient servant,

J. H. GRISDALE.

Director, Dominion Experimental Farms.

The DIRECTOR, April 3, 1914.

Dominion Experimental Farms,

Ottawa, Ont.

DEAR SIR,—I have the honour to submit herewith a manuscript entitled "Flax for Fibre, its cultivation and handling," which has been prepared by Mr. John Adams, M.A., Assistant Dominion Botanist.

Mr. Adams, from many years of intimate association in Ireland with the flax industry, and from his technical and scientific ability, has been in a position to prepare a very clear and comprehensive account of the principles of successful cultivation and handling of flax for the production of fibre which will be found most useful at this stage of enhanced interest in an industry [illegible] there certainly is a wide scope in suitable localities in the Dominion of C[illegible].

I beg to recommend the publication of the manuscript as a bulletin of the second series of the Experimental Farms.

I have the honour to be, sir,

Your obedient servant,

H. T[illegible]SSOW.

Dominion Botanist.

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FLAX FOR FIBRE: ITS CULTIVATION AND HANDLING.

HISTORICAL INTRODUCTION.

The cultivation of flax for fibre is of great antiquity, dating back to the earliest times of which we have any record. Microscopical investigation has shown that the bandages used for wrapping the Egyptian mummies were composed of linen; and, in the account of the destruction wrought by hail, one of the plagues of Egypt, it is recorded that "the flax and the barley was smitten, for the barley was in the ear, and the flax was bolled."

The plant is also figured in ancient Egyptian paintings, and these are of interest as showing that the crop was not reaped with a sickle like cereals, but was pulled up by the root.

In the British Islands the growing of flax for fibre, although it has been carried on to a certain extent over the greater part of the country at different times, has become firmly established only in the province of Ulster in Ireland. Its cultivation in that country by the Keltic inhabitants is also of very ancient date. In the Brehon laws, which date back long before the Christian era, there are various references to flax and to the implements employed in its manufacture. It is of interest to note that here also the crop was pulled up by the root, and that steeping in water was the recognized method of retting.

The crop, however, in Ireland did not assume very important proportions until near the close of the seventeenth century, when large numbers of Huguenot refugees settled in the North of Ireland, bringing with them their spinning wheels and looms, and an acquired skill in the manufacture of flax products. With the formation of the "Board of Trustees of the Linen and Hempen Manufactures of Ireland" in 1711, and the administration of government grants in aid of the flax industry by that body, the record has been one of continued progress to the present time. The acreage under cultivation has varied greatly from year to year and, on the whole, has gradually declined. In recent years only about one-fourth of the fibre used in the linen industry has been grown in Ireland, the rest being imported from other countries of Europe.

In the year 1809 there were 76,749 acres of flax grown in Ireland, in 1864 the maximum area of 301,693 acres was reached, and in 1898 there were only 34,469 acres grown, the lowest acreage for the century. From 1901 to 1910 there has been a slight increase in the area grown, the maximum being 59,659 acres in 1907. Looking back over the past century it will be found that a rise in the price of flax has usually brought about an increase in the acreage grown.

Among other European countries which produce flax fibre are France, Belgium, Holland, Austria, Hungary, and Russia. In the first four countries the acreage has steadily declined, but is stationary in Hungary and Russia. Since 1901 the area under flax in Russia has varied between 3½ and 3¾ million acres.

In Canada, flax has been grown for its fibre for a number of years in the province of Ontario, but there also the acreage has declined. According to official reports of the Provincial Government, the area devoted to the crop in that province was 12,128 acres in 1911, but less than half that amount in 1915, namely, 5,334 acres. Flax has also been grown for years to some extent in the province of Quebec.

The late Dr. Wm. Saunders, Director of the Dominion Experimental Farms, endeavoured to stimulate the interest taken in this crop by the publication of Bulletin No. 25 in the year 1896. Later, in 1906, he published Bulletin No. 59, dealing with the same subject and describing the result of tests made in growing flax for fibre in the different provinces of Canada.

Dr. C. E. Saunders has been engaged for a number of years in improving the varieties of flax by breeding from selected strains. Prof. C. A. Zavitz, of Ontario Agricultural College, Guelph, has experimented with a number of different varieties of flax in order to determine the best rate of sowing and the yield per acre. Some of his results will be found quoted farther on.

DESCRIPTION OF THE PLANT.

Flax or lint, known botanically as *Linum usitatissimum* L.—the Latin name means common or ordinary flax—is an annual, that is, it completes its whole life-history in a single season. It has delicate roots, a slender wiry stem about 2 to 3 feet high, narrow leaves, and blue, sometimes white, flowers. The fibre, to which it owes its strength and its chief value, is situated near the outside of the stem. If a fully grown flax stem is cut across the middle with a sharp knife or razor and examined with a small magnifying glass, it will be seen to consist of three regions. In the centre is

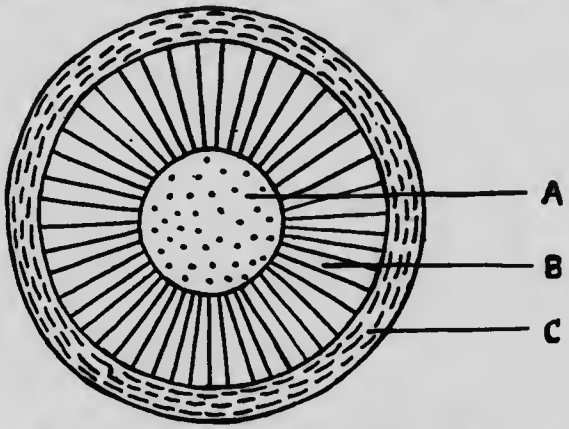

FIG. 1.—Diagram of the transverse section of a flax stem.
A. Pith. B. Woody zone. C. External layer.

a soft region known as the pith, which is sometimes hollow (fig. 1A). Surrounding the pith and nearly equal to it in width is a much harder and denser region known as the woody zone (fig. 1B). The pith and the woody zone together make up what is known as the "shive," or "shove." Outside the woody zone is a much narrower region, the external layer (fig. 1C), in which the fibre-bundles are situated. These fibre-bundles, two of which are shown in fig. 2, are frequently separate from each other, but it often happens that they run into each other at the edges. The number of individual

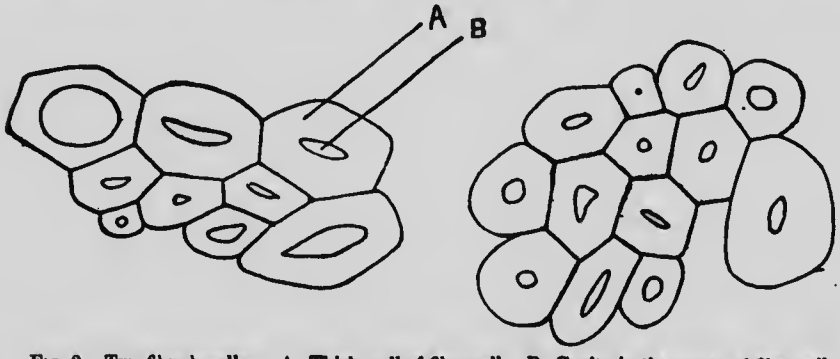

FIG. 2.—Two fibre-bundles. A. Thick wall of fibre-cell. B. Cavity in the centre of fibre-cell (highly magnified).

fibre-cells in the bundle also varies; those in the figure contain thirteen and nine, respectively. The fibre-cells shown in the figure can only be seen when magnified by a microscope.

The flowers on the same individual plant open in succession and, in consequence, all the seeds do not ripen at the same time. Each seed-boll or capsule is dry, when ripe, and contains ten or sometimes fewer brown seeds. The capsules open by a series of narrow chinks, but these are not sufficiently wide to allow the seeds to fall out (fig. 3).

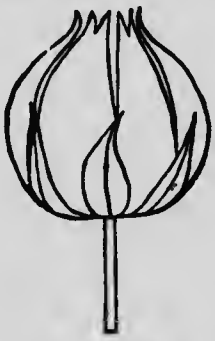

FIG. 3. Ripe seed-boll or capsule.

When flax is sown thinly, each plant is extensively branched and shrub-like, and the ripening of the capsules extends over a longer period, as the number of the flowers is much greater. Such a plant has very little value for fibre. When the seed is sown sufficiently thickly each plant produces a tall unbranched stem like that of a forest tree, and has only a few flowers at the top (fig. 4). This is the type of plant aimed at in growing flax for fibre.

Fig. 4. Flax plant grown for fibre.

CLIMATE.

Flax has been grown for fibre for a number of years in southwestern Ontario. The fibre produced appears to be of good quality, but is used chiefly for threads and twines. If the test of quality of flax fibre be its suitability for manufacture into linen, we have no information at present as to how Canadian-grown flax compares with that grown in European countries in this respect.

For the production of good fibre a climate with a long and moderately warm growing season, that is not liable to drought, and where there is a considerable amount of moisture in the air, is the most suitable. These requirements are best met by the western part of British Columbia.

As the average yield per acre of most crops is greater in British Columbia than in any other province of the Dominion, it is extremely probable that flax would be no exception to the rule. This is borne out by the trials of different varieties of flax made by Dr. C. E. Saunders in 1915. When the same two varieties were grown at different Experimental Farms throughout Canada, those grown at Agassiz, in British Columbia, produced fibre of a quality that was much superior to all the others.

Flax for fibre has been grown experimentally near Puget Sound, in the State of Washington, U.S.A., where the climate is similar to that of British Columbia. This flax was sent to Ireland for retting and preparing according to the usual method there. The report on this sample was that it compared very favourably with the Belgian product.

In addition to western British Columbia and southwestern Ontario, it should be possible to produce flax of good quality in those parts of the province of Quebec lying near the river St. Lawrence, and also throughout the Maritime Provinces generally.

SOIL.

Flax can be grown on a great variety of soils. Any soil that is suitable for the growth of cereals and other farm crops may be expected to give similar results, when sown with flax. Where choice is possible, a sandy loam is to be preferred. As uniformity in all characters is the most important point in connection with the production of flax fibre, it is advisable to choose a field that is as level as possible, and has a uniform type of soil so that the moisture-holding capacity will be similar throughout.

ROTATION.

Flax should not be sown on the same land oftener than once in five to seven years. Its exact place in the rotation varies, but the common practice is to sow after corn or some other cereal, or on land that has been in sod for several years. A crop of flax should not succeed mangels, as the soil is apt to be deficient in potash in that case.

MANURES.

Stable manure should not be applied to land immediately before sowing with flax, as it is liable to promote the growth of wood and leaves without a corresponding increase in the amount of fibre. It is better to manure heavily some previous crop in the rotation, and apply no manure to a crop of flax except potash in an artificial form, and then only where the land requires it. As potash is not at present available, owing to the war, wood ashes may be used wherever they can be obtained. In districts near the sea it may be possible to apply seaweed to some previous crop, as it contains a considerable amount of potash.

From very early times flax has had the reputation of being an exhaustive crop. Judged by its effect on the yield of subsequent crops there seems to be little foundation for this belief. On the other hand, when the crop is pulled, there is none of it left in the soil except the very fine roots, whereas, in the case of a crop of wheat, all the roots are left in the soil, and several inches of stubble are ploughed under in addition. In this sense flax removes more from the soil than other crops.

Analysis of the plant should throw some light on this problem, but, at the present time, the results of analyses made by different investigators are so discordant that no general conclusion can be drawn. In all probability there is considerable variability in the chemical composition due to differences of soil and climate.

PREPARATION OF THE LAND.

The preparation of the land should be such as will reduce it to as fine a state of tilth as possible. It should be ploughed in autumn to a moderate depth, if light, but to a greater depth if heavy, and should be frequently worked in spring to pulverize it thoroughly. Land that is badly infested with weeds should not be used for flax, as weeding must be done by hand after the seed germinates. The seed-bed should be compact, and to accomplish this it will be necessary to roll it, either before the seed is sown or after. Sometimes the land is rolled both before and after sowing, the practice depending largely on the nature of the soil. If the soil is so soft that the horses' feet leave a deep impression, the seeds, when sown on the rolled surface, will

have a tendency to accumulate in these hollows, and will probably be buried more deeply; hence the crop will not be so uniform. On the other hand, if the soil contains a considerable amount of clay, the practice of rolling after sowing the seed will tend to make the surface crust even more readily after rain.

SEED.

The seed used should be that of a fibre-producing flax, and not that of a flax grown solely for oil. If possible, Russian or Dutch seed should be obtained, or the produce of such seed grown in Canada. It would be advisable for a farmer to allow a small portion of his crop to ripen its seeds fully for next year's sowing, sacrificing the fibre, or, at any rate, keeping it separate from the rest. Various varieties of flax are grown, some being blue-flowered, others white-flowered. Blue-flowered flax is considered to give a better quality of fibre

Flax seed often contains immature seeds and weed seeds; and it is very desirable that these should be got rid of by re-screening and re-cleaning. It is usually impracticable to do much weeding among a growing flax crop, and weeds are a great nuisance at harvesting time. Not only is time lost in disentangling them from the flax stems, but weeds such as Canada Thistle with prickly leaves inflict serious injury on the hands of the pullers. Flax seed that contains Dodder should not be sown.

After the seeds have been re-cleaned, a sample may be sent to Ottawa to be tested for germination, but any farmer can do this readily for himself in the following manner: Take two flower pots, each measuring 8 inches in diameter across the top; fill them to within one inch from the top with sifted garden soil, which should be moderately damp and level on the surface; count 200 flax seeds taken at random, and scatter 100 on the surface of the soil in each pot; with a small piece of smooth board

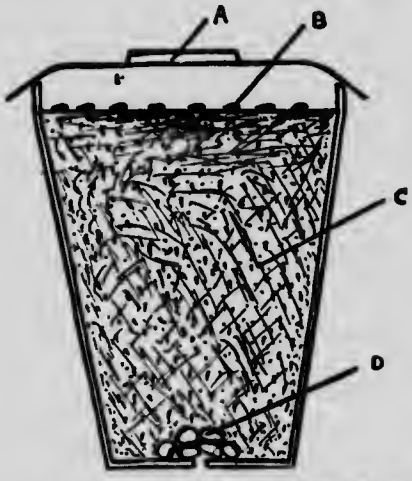

FIG. 5.—Simple apparatus for germinating seeds. A. Plate. B. Seed. C. Soil. D. Small stone.

press the seeds gently into the soil, but do not cover them; place a large plate bottom upwards over the surface of the pot to keep in the moisture (fig. 5); place the two flower pots in a moderately warm kitchen, taking care that the soil does not become too dry. After three days remove on the point of a needle the seeds which have germinated, and count them. The average of the two lots will give the percentage of germination.

DISINFECTION OF SEED.

Flax is subject to several diseases which may be carried by infected seed. Before sowing, the seed should be treated as follows:—

Spread the seed in a thin layer on a clean floor or a sheet of canvas. Spray it with a solution of formalin consisting of one ounce of formalin in ten quarts of water, mixing the seed thoroughly so that each seed is covered with the solution. Two quarts of the solution will be sufficient to spray one bushel of seed. Continue to turn and mix the seeds until they are quite dry.

AMOUNT TO SOW.

The amount of seed to sow per acre will depend on several circumstances, such as the nature of the land and the germination of the seed when tested. It will be advisable to sow a little more thickly on heavy soil than on light soil, as in the former a larger number of seeds will probably die without germinating. The seeds must be sown sufficiently close together to keep the plants from branching, but there are some other points to be taken into consideration. From investigations conducted at the Central Experimental Farm during the past year it has been found that flax stems of medium thickness gave a larger percentage of fibre than stouter and coarser stems taken from the same bundle. It therefore follows that the seed should be sown sufficiently closely to produce stems of medium thickness. If it be assumed that there should be at least one plant to each square inch, we can readily form an estimate of the minimum amount of seed to sow. Calculations based on an actual weighed sample of 100 seeds showed that there were 106,728 seeds in a pound. Some samples will give fewer seeds, others a larger number per pound. Taking the above number of seeds per pound, and assuming that the seeds sown are absolutely free from impurities and that every seed will germinate, and that we wish to have one plant per square inch, then 58¾ pounds of seed will give this result. This is a little over one bushel if 56 pounds are reckoned to the bushel. But one plant per square inch is a comparatively thin rate of seeding, and no sample of seed is absolutely pure, nor will a sample of seed that germinates 100 per cent in the laboratory attain this germination rate when sown in the field. Consequently a thicker rate of seeding will be necessary. A good sample of flax should be nearly free from impurities and, if the germination after three days is 95 per cent or more, the seed should be sown at the rate of 1¾ bushels per acre; if the germination comes between 85 and 95 per cent, 2 bushels per acre should be sown; and with a germination of 75 to 85 per cent, 2¼ bushels will be necessary. It is worth remarking that, if the seeds are sown too closely together, the stems may become lodged, or may rot during wet weather. As showing the result of sowing different amounts of seed per acre, the following figures from a report of investigations conducted by Prof. C. A. Zavitz at Guelph, Ont., are of interest. During each of the five years 1905-9, inclusive, four varieties of flax were sown at different rates per acre. The rate of sowing, height, and yield per acre were as follows:—

Amount Seed Sown.	Height of Crop in Inches.	Yield of Straw in Tons.	Yield of Grain in Bushels.
1	29	1·55	14·9
2	29	1·68	15·2
3	29	1·96	18·6
8	28	2·24	19·9
12	27	2·35	20·2
16	26	2·24	18·0

TIME TO SOW.

Flax should be sown as soon as the ground can be got into proper condition. Light frosts do not injure flax seedlings; only a frost sufficient to freeze the ground

solid is likely to do any harm. Sowing can be carried out earlier on light soils. Heavy land, that is cold and wet in spring, requires longer to dry to the proper condition. In order to lighten somewhat the work of harvesting, it will be sometimes advisable to sow on two different dates, with an interval of a week to ten days between. As the crop will not be all ready for harvesting at the same time, the work of handling it will be better distributed

METHOD OF SOWING.

Flax seed is generally sown broadcast, and it will be advisable to sow when there is no wind. If sown by hand, great care will be necessary to have the distribution uniform, as the seed is so slippery. The seed may be sown with a drill in rows 4 inches apart, after which it should be harrowed in a direction across the drilled rows. The seed should be covered to a depth of about half an inch. After the seed has been covered, the surface is usually rolled. If the land contains a considerable amount of clay, it will be advisable not to roll it after seeding, as the surface is apt to form a hard crust after rain. In such case the surface should be rolled before sowing. The young flax plants are less likely to suffer from drought, if the seed-bed is compact. Clover is frequently sown with flax, and makes a considerable growth the first year.

WEEDS.

If flax is sown, as it should be, on clean land, and the seed sown is free from impurities, very little weeding will be necessary. Any weeding that is attempted should be done by hand, and should be carried out before the crop is 6 inches high. The persons employed should wear rubber-soled shoes, and should proceed in a direction against the wind. This will tend to straighten any plants that are bent down.

Red Root Pigweed (*Amaranthus retroflexus*, L.) and Small Bindweed (*Convolvulus arvensis*, L.) are difficult to separate from flax when it is being scutched. Flax should not be sown on land that is infested with these weeds.

The seeds of Lady's Thumb (*Polygonum Persicaria*, L.), Pale Persicary (*Polygonum lapathifolium*, L.), and Small Darnel (*Lolium linicolum* A. Br.) are difficult to separate from flaxseed, and these species should be looked for in the crop.

Flax Dodder (*Cuscuta Epilinum* Weihe) lives as a parasite on the flax plant, twining round the stems and deriving its whole nourishment from them. Any small patches of Dodder in the field should be cut and burned.

Wild Mustard (*Brassica arvensis* Ktze.), when growing in cereal crops, can be controlled by spraying with a 20 per cent solution of iron sulphate, or a 2 per cent solution of copper sulphate. It is doubtful, however, whether this remedy can be applied in the case of a flax crop. According to Professor Zavitz, of Guelph, a 20 per cent solution of iron sulphate injured the flax crop and, even with a 15 per cent solution, there was a moderate amount of injury. Professor Bolley states that flax should not be sprayed after it is 4 to 5 inches high. Other experimenters state that they have used a 3 per cent solution of copper sulphate without injuring the flax. Until further experiments have been made, spraying of mustard in a flax crop should be done with caution. If attempted, a knapsack sprayer should be used, and a 15 per cent solution of iron sulphate (15 pounds in 10 gallons of water) should be applied at the rate of 52 gallons per acre.

DISEASES

The chief diseases of the flax plant are two in number, namely, Flax Wilt and Flax Rust. Flax Wilt (*Fusarium lini* Bolley) attacks the plant in its seedling stage and kills it. The germs of the fungus live in the soil, and the remedies are proper rotation of flax with other crops, and treatment of the seed with formalin before sowing.

Flax Rust (*Melampsora lini* D.C.), also known as Firing, attacks the plant usually when full grown, but rarely kills it. The fungus forms pustules on the stem and leaves, which are at first orange in colour, but afterwards turn black. The black spots tend to discolour the fibre. Nothing can be done to check the disease after it appears and, consequently, the crop should be pulled before it becomes badly discoloured. As the black stage of the rust appears rather late in the season, early sowing is advisable. Seed should be selected from a healthy crop, and proper rotation in growing a crop of flax should be followed.

HARVESTING.

Flax, when grown for its fibre, is always pulled by hand, not cut. The exact time to pull the crop so as to obtain the greatest financial return from the fibre and seed combined varies to a certain extent with conditions of labour and climate. It is not possible, however, to ripen all the seeds fully and obtain the best quality of fibre at the same time. In growing the crop for fibre, the seed must be considered as a secondary product. In Ireland, it is not the custom to save any seed and, in consequence, the crop is not dried previous to retting. In other European countries the practice is to dry the flax after pulling, remove the seeds, and ret the straw afterwards.

From investigations, both chemical and microscopical, conducted at the Central Experimental Farm during the past year, it appears that flax fibres undergo a certain amount of lignification as they grow older, that is, they become harder and more brittle instead of remaining soft and silky. Flax, therefore, should be pulled before this lignification process has gone too far. Recent investigations carried out by Eyre and Fisher, in England, tend to show that the best yield of both fibre and oil may be obtained if the crop is pulled exactly in the middle of the period between flowering and final ripening. When the lower half of the stem is yellow and the leaves have fallen off, the crop may be considered as ready for harvesting. It is easy to determine when, on an average, the first seed-boll on each plant is ripe by crushing it between the fingers. The sap has been all absorbed, and the brown seeds will fall out readily. It is also easy to estimate roughly when half the capsules are ripe by pulling up a plant and counting the ripe and unripe seed-bolls present. It will be a good plan to pull between these limits, that is, after the first seed-boll has ripened and before half the seed-bolls are ripe. The sheaves are then set up in stooks to dry.

It is of great importance to keep the tips of the roots at the same level when pulling, as this renders the subsequent handling of the flax much easier. Any soil that adheres to the roots should be shaken or knocked off. The bundles should be tied rather loosely, should be uniform in size and of about 8 inches in diameter. A few stalks of the flax are generally used to make a band for tying. It will be found an advantage, if the weather is wet, to tie the sheaf not in the middle, but nearer the top end. Instead of putting the sheaves in stooks, each sheaf will, if spread out at the base, stand alone and will dry much more quickly after rain (fig. 6).

As flax has a delicate root, it is readily removed from the ground, and the work can easily be done by children. About as much flax as can be conveniently grasped between the hands is caught a short distance below the seed-bolls, the right hand having the thumb lowest in position. Care should be taken to avoid pulling off the seed-bolls, as this is likely to happen if they become entangled. Each handful, as pulled, is laid flat on the ground and more flax is placed on the top, until there is about sufficient to form a bundle. It is much more satisfactory for one and the same person to tie the bundles, as they are in that case more likely to be uniform in size and to be tied with the same degree of tightness. Any short patches of flax in the field should be kept separate from the general bulk.

At the average rate of pulling, four men will be required to pull an acre in a day. Experiments have been made with machines for pulling flax, but further testing is necessary before they can be recommended. As there is very little fibre in the lowest inch of flax stem, it might be possible to cut the crop with comparatively little waste. This would only be practicable where the crop is of considerable height, and where the land has been rolled after sowing. The great difficulty in the way of devising a successful machine for handling flax at this stage is the ease with which the seed-bolls become entangled.

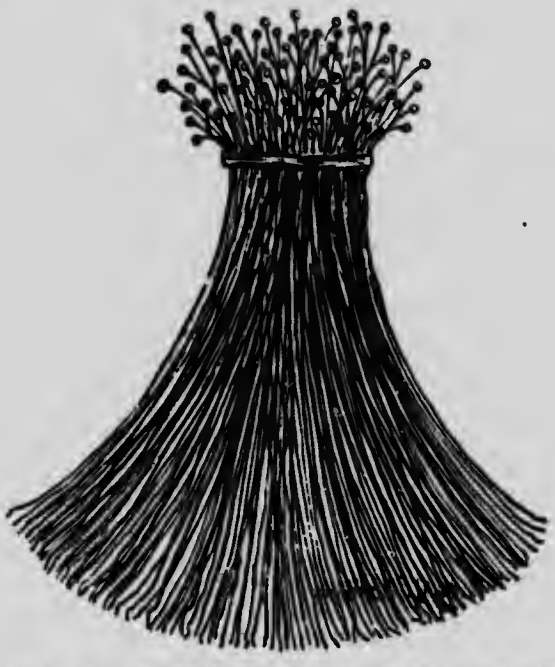

FIG. 6.—Flax bundle tied near the top and spread out at the base.

REMOVAL OF THE SEED.

The dried flax may be put into stacks, or stored in a barn until time can be found to remove and clean the seeds. If, however, it is intended to ret the flax during the season in which it is grown, the removal of the seed-capsules will require to be done at once, as retting cannot be accomplished satisfactorily if the weather is too cold. It would seem quite possible to save a considerable percentage of the seeds and ret the straw the same season without drying the flax in stooks. A flax plant branches slightly at the top, and the amount of fibre contained in these branches is, if the seed has been sown sufficiently thickly, of comparatively little moment. When the flax has been pulled and tied into bundles, it should be comparatively easy to remove these branching tops, at the ends of which the seed-bolls are situated, with a single stroke of a large, sharp knife. The seed-bolls could be placed on a large cloth and turned until they are dry, and the flax straw could be immediately retted. It is a method which might be used with advantage during wet weather, and it is practised to a considerable extent in parts of Russia.

Assuming that the flax has been dried, there are various methods in use for removing the seed. One of these is "rippling," which consists in pulling handfuls of flax over and between iron teeth placed close enough to pull off the capsules (fig. 7). The teeth of the rippling comb should be round in section and the spaces between should be about three-sixteenths of an inch. The capsules are afterwards crushed on the floor by a wooden mallet, or by a roller drawn over them, and the seeds can be separated by a fanning mill.

The capsules may be crushed without rippling by placing the bundle on a stout board on the floor and pounding it with a mallet. But, if the bundles have been carelessly tied, rippling has the advantage of enabling the operator to even the ends and remove weeds before tying up again. Another method is to pass the handful of flax between smooth rollers pressed together by springs. The crushed capsules are then passed through a fanning mill. There is a threshing machine in use in eastern

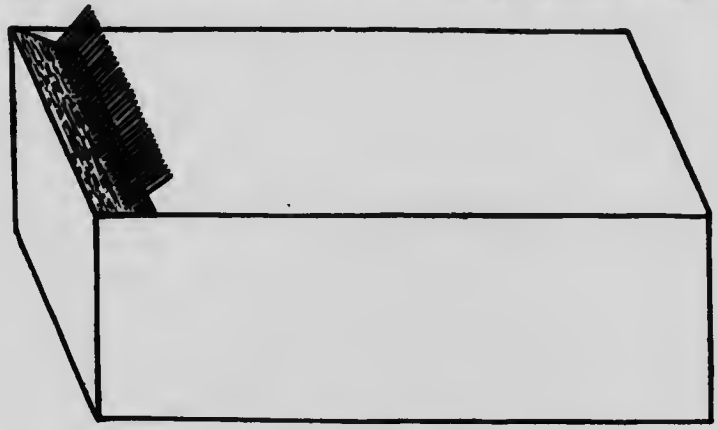

FIG. 7.—Apparatus for rippling.

Michigan which, it is claimed, keeps the ends straight, and afterwards binds the flax again into bundles. This machine is said to thresh 15 tons of flax straw a day. Whatever type of machine is employed, care must be taken to avoid crushing or injuring the flax straw. After removing the capsules, the straw should be tied into moderately loose bundles of about the same size as before. Any weeds that are noticed in the sheaves during the threshing should be removed, and the ends of the bundles should be squared before tying up. Flax screenings are sometimes used for feeding purposes, but should be employed for this purpose in small quantities only, as there are several records of cattle and sheep being poisoned by eating them.

As flax seeds are liable to absorb moisture readily, if kept in a damp state, and to heat in consequence, it is much easier to keep them dry if allowed to remain in the seed-bolls as long as possible. It is very important that sacks of cleaned flax seed should be stored in a dry, airy place. The dried flax straw must also be kept dry until the time for retting arrives. If allowed to become damp, moulds will develop and the fibre will be seriously injured.

RETTING OR STEEPING.

The object of retting is to bring about certain chemical changes in the flax stem so that the fibres may be readily separated from the shoves. It is really the first stage in the manufacture of flax, and it is open to question whether this operation should be carried out by the farmer, or should be undertaken, together with the next stages of breaking and scutching, by the flax manufacturer.

There are two methods of retting in common use, namely, dew-retting and water-retting. In the former case the flax is spread in a thin layer in rows on the grass, which should be short and have a level surface. It is turned at frequent intervals with a long pole. The length of time required for retting varies with the character of the weather, and will extend over several weeks. Two acres of grass land will be required for each acre of flax. When it is found that the fibre separates readily from the shoves, it should be lifted carefully on a dry day and tied up again into bundles. Provided the flax straw is perfectly dry it can be tied up into much larger bundles than before. If the weather is wet, drying may be hastened by setting the flax up on end as shown in fig. 8.

Dew-retted flax is not so uniform in quality as water-retted flax, and fetches a considerably lower price. This is what might be expected, as it is much more exposed to weather conditions.

Water-retting produces the highest quality of fibre, but it requires much more judgment and precision to carry the process out properly. Fermentation due to the action of bacteria goes on much more rapidly in the water. As mentioned previously, the fibres occur more or less in bundles. The object of retting is to break down and dissolve the tissues between and around these bundles, so that the latter may be

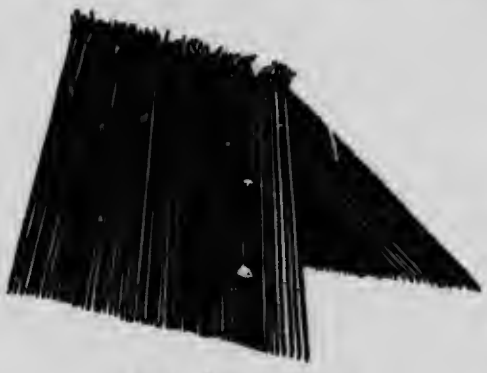

FIG. 8.—Flax set up to dry.

readily separated. The fibre-cells composing the bundle are held together by a gummy substance, and, if the retting is too prolonged, this gummy substance also dissolves and the fibre-cells become separated from each other. The result is that the flax stem, when pulled has lost its strength and breaks across as easily as a piece of wheaten straw. Much, therefore, depends on taking the flax out of the water just at the right time. On the other hand, if the flax is retted insufficiently, it will be much harder to separate the fibre from the shove. The work of scutching will be more difficult to carry out, and will be accompanied by greater waste of fibre. Of the two evils, however, the second is certainly the lesser.

Although the main features of water-retting are described below, it must be understood that a full understanding of the subject in all its details can only be gained by several years' experience.

The water used for retting should be soft and free from iron. It is possible to treat water containing lime with chemicals so as to soften it, but this adds considerably to the trouble and expense. The pond used for retting should be constructed, if possible, in a clay soil. Where soft water is not available, it may be possible in some cases to fill the pond with rain water some time before it is required, but it entails considerably more trouble to put the flax bundles into the tank, if it is already full of water. The amount of water used in proportion to the flax steeped varies in different distri-

Where a large quantity of water is used, the flax is lighter in colour and the smell is said to be less objectionable, after it is taken out of the water. The same tank can be used any number of times for retting, but it is advisable to empty it and fill with fresh water after each lot of flax has been taken out. Water that flax has been steeped in has a strong odour and blackish colour, and is poisonous to fish.

Retting may be carried out from May to September. The time required for immersion varies with the temperature. Last year at the Central Experimental Farm some small samples of flax were retted in three days, but usually from five days up to twelve days, or longer, will be required. The best temperature for retting is about 72° F., but care should be taken to test the water both at the bottom and at the surface of the pond. The water at the surface on a sunny day will be several degrees warmer.

The tank for retting should be constructed several months before it is required. It should be about 3½ feet deep, and should not be more than 6 or 8 feet wide. About 360 square feet of water surface should be allowed for one acre of flax. The tank should be constructed near a stream from which it can be filled when desired. Its construction should also admit of the water being run off before the flax is taken out. A pipe with a wooden plug at the end makes a suitable outlet. It should be placed to leave about 9 inches of water in the tank. It can be dislodged when desired by a long pole (fig. 9). When flax is retted green, that is without drying, it should be put into the tank as soon as possible after pulling, and should not be left exposed to the sun any longer than necessary. All the flax in any one tank should be put in the same day; it should also be taken out on the same day.

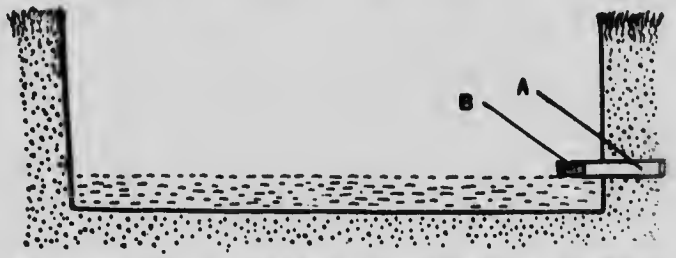

Fig. 9.—Tank ready for filling with flax. A. Outflow pipe. B. Wooden plug.

The method of procedure is as follows: The flax, having been cut close to the side of the tank, and the wooden plug having been inserted, a man stands in the few inches of water and places the flax bundles, handed to him by another person on the bank, in a slight slope against the lower end of the pond. The bundles are placed with the butt end downwards, and should not be pressed too closely together, so that water may circulate around and through the bundles (fig. 10). It is important that the bundles should be of the same size and not too tightly tied. This part of the work may also be done by stretching two stout planks across the dam for the man to stand on, the bundles being placed in position by means of a fork; but, unless the bundles have been properly tied, they sometimes fall to pieces when lifted on a fork. When all the flax has been put into the tank, stones of moderate size are placed on the top. These are for the purpose of keeping the flax under water after fermentation has commenced. The water is then turned on and allowed to flow until the flax is well covered. No water should be allowed to flow through the dam during the time of immersion, unless it is found that the dam has leaked owing to improper construction. After a day or two it may happen that some of the flax rises above water owing to the accumulation of gas bubbles. When this occurs, it should be pushed under water and more stones added. From about the fifth day onward the flax should be tested every morning and evening to see if it is properly retted. A few straws should be pulled out from different parts of the dam and examined in the middle of their length. If the flax stem, when bent,

snaps across sharply, and the central woody zone can be readily separated from the fibre, the flax has been long enough immersed. The water should be allowed to run off with the exception of a few inches in the bottom to wash the mud off the roots of the flax, as it is taken out. Beginning at the upper end of the dam, a man stands in the water and throws the bundles on to the bank, or they may be removed by a man with a fork standing on planks stretched across the dam. As the bundles are now so much heavier, there is even greater danger of them falling to pieces, if carelessly handled. Any mud that adheres to the hurds should be washed off before they are thrown out. In case it is found that the flax, when examined in the evening, is sufficiently retted, the water should be at once let off and the flax thrown out of the dam. It will take much less harm from lying on the bank over night than if allowed to remain in the water. After all the flax has been removed from the water, clean water should be allowed to flow through the tank, otherwise it will become a favourite breeding place for mosquitoes.

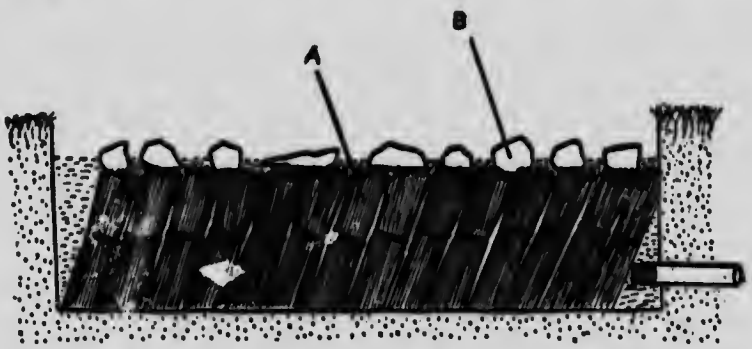

FIG. 10.—Tank filled with flax. A. Bundle of flax. B. Stone.

A description of the "Feuillette" system of retting, in which the operation is carried out in covered tanks at any time of the year, the water being heated to the requisite temperature, will be found in "Flax Fibre," Pamphlet No. 1 of the Publications Branch, Ottawa, May, 1915. This system is somewhat elaborate and expensive and would prove satisfactory only where a number of flax-growers co-operate.

A fuller account of the systems of retting followed in various countries of Europe will be found in Dr. J. V. Eyre's "Report on the Possibility of Reviving the Flax Industry in Great Britain," issued in 1914 by the Board of Agriculture and Fisheries, 4 Whitehall Place, London, S.W., England; Price, fourpence, post free.

DRYING.

After flax is taken from the dam it is left on the bank for about an hour to drain, and is then carted to a grass field to be spread. As in the case of dew-retting, it is spread in a thin layer on the grass (fig. 11). The individual straws should be separated from each other as far as possible by shaking each handful as it is being spread. Owing to the gummy substance present, the flax straws have a tendency to cling together, especially if the bundle has been too tightly tied. Unless the straws are separated, the spread flax will not dry uniformly. As soon as the flax is thoroughly dry, it is then collected and tied up in bundles. If left on the grass for a few days, it will become lighter in colour, but there is danger that the quality of the fibre may be affected. Both in the spreading and lifting, care must be taken to keep the tips of the roots at the same level.

Owing to the unpleasant smell and the stooping posture, the spreading of flax is rather arduous work, and there seems to be no valid reason why the system of "gating"

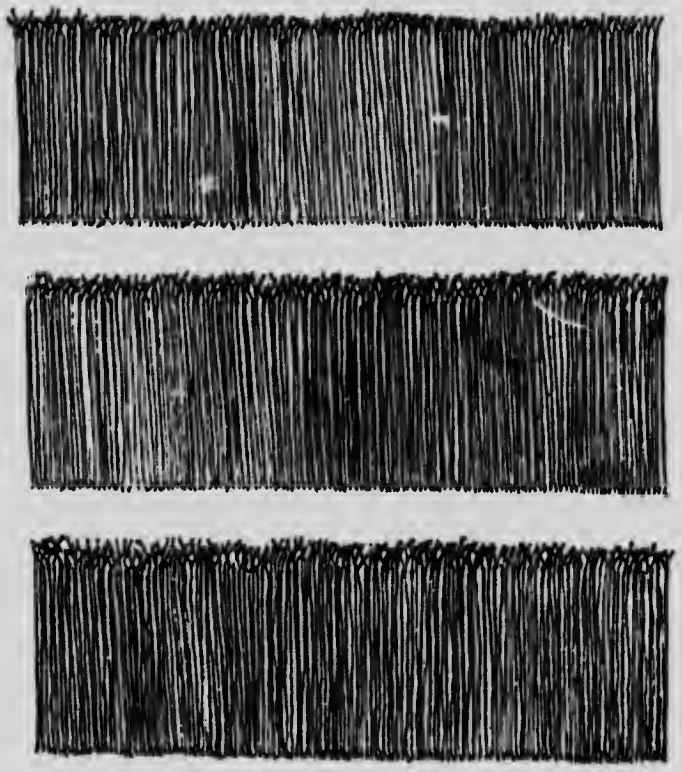

FIG. 11.—Method of spreading on the grass.

should not be more largely adopted. By this method the bundles are set up on end for an hour or more to drain. The stones taken from the dam, before the flax is removed, can be used as a support for the first row, if they are piled on top of each other, or the flax bundles may be laid against a low wooden rail. When the water has drained off sufficiently, the band is removed, the bundle opened out, and the flax straw, after being shaken, is set up against each side of a wooden rail about 18 inches from the ground (fig. 12). When quite dry it can be tied up into large bundles, and should then be

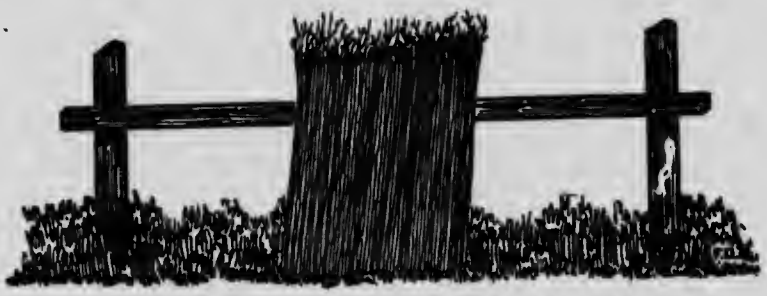

FIG. 12.—Method of "gating" flax. A stout nail driven into the upright stake serves as a rest for the horizontal rail.

stacked or housed. The advantages of gating are: that the flax is much easier to dry if the weather is wet, less ground is required, and much less stooping is necessary on the part of the worker.

SCUTCHING.

Scutching is the operation by which the fibre is separated from the central woody zone or shove. It is usually performed during the winter months, and requires an experienced workman. Flax before being scutched is first passed through a "brake." This consists of a number of rollers, some grooved, some smooth, and revolving at different rates. As the flax straw passes between these, the shove is crushed and broken into short lengths, and is easily knocked off from the fibre during scutching. The principle of braking flax is shown in fig. 13.

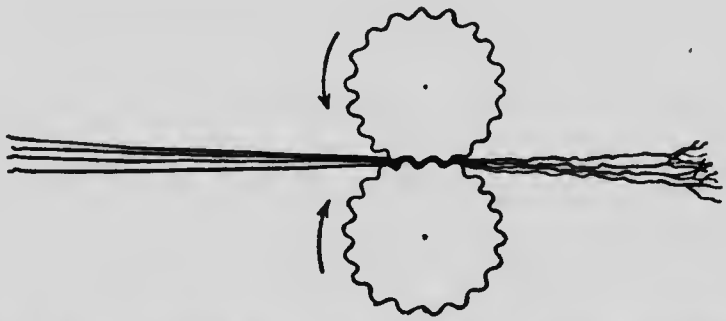

FIG. 13.—Flax passing between two rollers of the brake. The arrows indicate the direction of movement of the rollers.

The necessary appliances for scutching consist of an upright frame or stock with a notch cut in one edge (fig. 14). Through this notch the operator holds a handful of flax which has already passed through the brake, and the shoves are knocked off

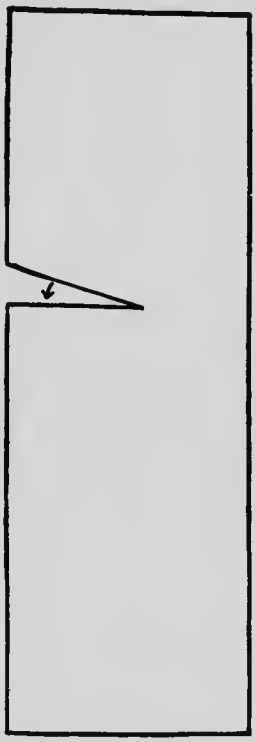

FIG. 14.—Scutching stock or frame. The arrow indicates the direction of movement of the scutching blades.

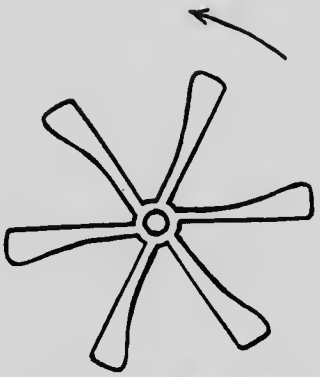

FIG. 15.—Scutching blades or handles. The direction of movement is shown by the arrow.

by the beating action of "blades" or "handles" attached to a revolving wheel (fig. 15). By carefully turning the handful of flax and subjecting it to the action of the blades, all the shoves are eventually removed and nothing but the fibre left. A careless scutcher will remove a large part of the valuable fibre in the form of waste or "tow" which sells at a much lower figure.

In Belgian mills the revolving wheel usually carries twelve wooden blades, while in Irish scutching mills there are six iron blades which are of a heavier type of construction, but revolve much more slowly.

It will be seen from the above description that the machinery necessary for braking and scutching is comparatively simple. Water-power may be used where available, or an oil engine, or an electric motor. Ten scutching stocks or more can be operated by the same shaft. As scutching flax is dusty work, one or more ventilators should form part of the equipment.

YIELD OF FIBRE.

No statistics seem to be available showing the amount of scutched fibre produced per acre in Canada, although there are figures showing the weight of dry unthreshed flax straw, the average for the province of Ontario being about 2 tons per acre. The yields of straw per acre at Guelph are given in the next section. The amount of flax

straw is not, however, by any means a correct guide to the amount of fibre present. Furthermore, small carefully weighed samples of flax, if scutched with special care, are apt to give a considerably higher percentage of fibre than an acre scutched by the ordinary methods. Several preliminary tests of small samples of flax, weighed before and after scutching, were made in 1915, but until they have been repeated and carefully checked it would probably be misleading to publish the figures.

For the ten years, 1901-10, the average yield for the whole of Ireland varied between 536 and 378 pounds per acre, the mean for the whole period being 463½ pounds. The highest yield obtained in Ireland was in the year 1852, when an average yield of 580 pounds per acre was obtained over an area of 137,008 acres.

YIELD OF SEED.

Although the figures quoted below refer in most cases to the amount of seed produced, where the crop is grown exclusively for that purpose and not for fibre, still they will serve a useful purpose in showing the amount of variation there is in different localities and in different years. It is only in the province of Ontario that the crop is grown both for fibre and seed, and the figures for that province as a whole may be taken as fairly representativ of the amount of seed obtained from a fibre crop. The experiments conducted at Guelph, however, seem to refer to seed production only, no mention being made of the fibre. The average yields of flax seed per acre for the whole ' inion and for the various provinces during the five years 1910-15 were as follo. . Canada, 11·27 bushels; Quebec, 11·14 bushels; Ontario, 16·44 bushels; Manitoba, 12·18 bushels; Saskatchewan, 11·17 bushels; Alberta, 11·53 bushels.

At Saskatoon, in the province of Saskatchewan, the yield of seed in 1915 varied from 18·27 to 26·50 bushels per acre. The average yield was 22 bushels, the highest yield being obtained after corn.

The yields in thirty-six districts in Alberta in 1913 varied between 5 and 27 bushels per acre, and in 1914 between 1·29 and 15 bushels per acre. The average yield in Alberta for the twelve years, 1903-14, was 9·21 bushels.

Prof. C. A. Zavitz, of Ontario Agricultural College, Guelph, carried on experiments with flax seed obtained from Ontario, Manitoba, Russia, and Holland. His results for the seven years 1905-11 were as follows:—

Variety.	Average Yield of Straw per Acre.	Average Yield of Grain per Acre.
	Tons.	Bushels.
Manitoba	2·51	17·55
Ontario Common	2·54	16·42
Russian	2·32	14·99
Holland	2·31	13·94

"The yields of flax per acre in 1911 were unusually light, owing to the exceedingly hot dry weather." The average yields per acre for that year were: Ontario Common, 8·7 bushels; Manitoba, 8·4 bushels; Holland, 7·7 bushels; and Russian, 7·4 bushels.

"In 1912, Manitoba flax gave an average of 30, and Ontario flax 28·1 bushels per acre. The highest yield in 1912 was obtained from Minnesota No. 25, which gave a yield of 32·9 bushels of seed per acre."

"In 1913 the highest results were obtained from the following varieties: Manitoba, 25·9; Ontario, 25·8; the Argentine, 22·8; and the Minnesota No. 25, 22·6 bushels per acre."

As there is no mention of the fibre, the presumption is that the foregoing plots of flax at Guelph were allowed to ripen their seeds fully before being harvested. Still the figures are of interest as showing how in the same locality there is great variation from year to year, according to the character of the season. It is safe to assume that in an ordinary year from one-half to two-thirds of the above amounts of seed could have been obtained, and at the same time a fibre of good quality.

PRICES.

In January, 1915, the price of flax at Belfast, Ireland, ranged from $434 to $607.50 per short ton for Dutch fibre, and was $369 per ton for Russian fibre. The price in December, 1915, was $700 per ton. These prices are the highest on record.

The price of flax seed at Winnipeg during November, 1915, ranged from $1.62½ to $1.89 per bushel.

GENERAL CONSIDERATIONS.

Flax for fibre is a difficult crop to handle, as so much of the work has to be done by hand labour. A farmer, who has never grown the crop before, should not attempt more than 1 or 2 acres at first. Apart from the value of the seed, there is little profit from the crop if damaged by bad weather or neglect at some stage of treatment. A small area properly looked after may realize as much profit as double the area carelessly handled.

The particular stage at which a farmer should dispose of his crop must be determined largely by local circumstances. Every stage described in the preceding pages, except scutching, can be done on the farm. There appears to be no reason why a farmer should not pull and dry the crop, remove and clean the seeds during the winter months when other work is slack, take out weeds and square the ends of the bundles of straw, and sell the straw to the scutch mill owner. The latter could carry on retting operations during the summer months and employ the same staff at scutching in the winter, thus having a more skilled supply of labour, and finding employment for them all the year round. Under some such scheme, farmers living at a distance of up to about 10 miles from the scutch mill could dispose of their crop. Green flax straw loses about two-thirds of its weight in drying. The dried straw after threshing loses one-third of its weight in the form of capsules and seeds. The dried threshed straw further loses one-sixth of its weight in the process of retting. This means that 270 pounds of freshly pulled flax will weigh 90 pounds after drying, 60 pounds after threshing, and 50 pounds after retting. Obviously the haulage to the nearest market is very much reduced if as much of the work of handling as is possible is done on the farm.

The scutch mill owner is in a much better position as regards marketing than the farmer. The fibre, which is the only important part of the flax stem, will average only about one-fifth of the weight of the retted straw; in other words, the 50 pounds of retted straw mentioned above will give about 10 pounds of fibre. The scutched fibre, when pressed and put up in bales of about 100 pounds each, occupies comparatively little bulk, and the freight even to a market several thousand miles distant amounts to only a comparatively small fraction of the value of the goods.

A farmer who is not within a reasonable distance of a scutch mill need not attempt to grow a crop of flax for fibre. As, however, the machinery required for the separation of the fibre is comparatively simple, it should not be impossible for a number of farmers in a district where water-power is available to co-operate and erect a small plant of their own.